We claim:

1. A single mode optical waveguide fiber having a radial and azimuthal asymmetric core comprising:

a core region in contact with a surrounding clad layer, at least a portion of the core region having a refractive index which is greater than the refractive index of at least a portion of the clad layer;

the waveguide having a centerline parallel to the long dimension of the waveguide, and the waveguide having at least one core sector bounded by a first and a second plane, and a segment of the core region periphery intersected by the first and the second plane, wherein the first and second planes each contain the centerline and form at the centerline an included angle $\varphi \leq 180°$,

in which, the core refractive index changes along at least a portion, Δr, of a pre-selected radius extending perpendicular to and outward from the centerline, and,

the core refractive index at least at a point at a pre-selected radius inside the at least one core sector has a value different from the core refractive index value at least at a point at the pre-selected radius outside the at least one core sector.

2. The single mode waveguide of claim 1, in which, the core region has a cylindrical shape and a point in the core region has cylindrical coordinates, radius r, azimuth angle φ, and centerline height z, and the radius of the core region is $r = r_o$, and the pre-selected portion of the radius is in the range $0 < \underline{\Delta} r \leq r_o$.

3. The single mode waveguide of claim 2, in which, the pre-selected portion of the radius is the segment $\Delta r = r_2 - r_1$, where, $0 \leq r_1 < r_2$ and $r_2 < r_o$.

4. The single mode waveguide of either claim 2 or claim 3 in which the pre-selected portion of the radius lies along any radius in at least one sector having included angle $0 < \varphi \leq 180°$.

5. The single mode waveguide of claim 2, in which, the pre-selected portion of the radius Δr is in the range $0 < \Delta r \leq r_o$, the azimuth angle of the radius is in the range $0 \leq \varphi \leq 360\,^{\circ}$, and the radius is drawn from any point z along the centerline.

6. The single mode waveguide of claim 2, in which, the pre-selected portion of the radius is the segment $\Delta r = r_2 - r_1$, where, $0 \leq r_1 < r_2$ and $r_2 \leq r_0$, the azimuth angle of the radius containing the segment is in the range $0 \leq \varphi \leq 360\,^{\circ}$, and the radius containing the segment is drawn from any point z along the centerline.

7. The single mode waveguide of claim 2, in which, the core has 4 sectors of equal volume numbered consecutively from 1 to 4 in a counter-clockwise azimuth direction, and the boundary planes of each sector have an included angle of $90\,^{\circ}$, and sectors 1 and 3 have a radial change in refractive index defined by a function f(r), and sectors 2 and 4 have a radial change in refractive index defined by a function g(r).

8. The single mode waveguide of claim 7, in which, g(r) is a step index and f(r) is an α-profile.

9. The single mode waveguide of claim 2, in which, the core has 4 sectors of equal volume, the bounding planes of each sector having an included angle of $90\,^{\circ}$, the refractive index profile of each sector having a central portion of radius r_c and relative index Δ_c, extending between the planes bounding the sector,

a first annular region in contact with the central portion, having outer radius r_1, relative index Δ_1, and extending between the planes bounding the sector,

a second annular region in contact with the first annular region, having outer radius r_2, relative index Δ_2, and extending between the planes bounding the sector,

a third annular region in contact with the second annular region, having outer radius r_3, relative index Δ_3, and extending between the planes bounding the sector,

a first volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the first plane bounding the sector

and bounded on a second part of its surface by a part of the first, second, and third annular regions,

a second volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the second plane bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions, wherein,

each of the remaining three sectors contain embedded volumes having surfaces bounded in a way corresponding to the volumes embedded in the first sector, wherein, the relative indexes and the radii follow the inequalities,

$0 \leq r_c < r_1 < r_2 < r_3 \leq r_0$ and $\Delta_c \geq \Delta_2 > \Delta_1 \geq \Delta_3$.

10. The single mode waveguide of claim 2, in which the core has three sectors, and each sector comprises a volume of a first glass of constant refractive index embedded in a volume of a second glass of constant refractive index, in which the refractive index of the first glass is greater than the refractive index of the second glass.

11. The single mode waveguide of claim 10 in which each of the first glass volumes is an elongated body having its long axis aligned parallel to the centerline, wherein the perpendicular cross section of the elongated body is selected from the group consisting of a circle, an ellipse, and a parallelogram.

12. The single mode waveguide of claim 2, in which the core has three sectors, and each sector contains an elongated glass volume having a central portion, a first annular portion surrounding and in contact with the central portion, and at least one additional annular portion in contact with the annular portion which the at least one additional annular portion surrounds, wherein the long axis of each of the elongated structures is parallel to the centerline.

13. The single mode waveguide of claim 12 in which the central portion is a cylinder having radius r_c and relative index Δ_c, and the annular regions are tubes having respective outer radii r_i and relative index Δ_i, where $i = 1 \ldots n$, and n is the number of annular

portions, in which Δ_i for i = an even number is greater than Δ_i for i equal to an odd number.

14. The single mode waveguide of claim 2 in which the core has four sectors each sector comprising a first glass volume having relative index Δ_1, and embedded in the first glass volume of each sector is an elongated volume of a second glass having relative index Δ_2, wherein the respective elongated volumes are arranged symmetrically about the centerline.

15. A method of making a radially and azimuthally asymmetric single mode or multimode optical waveguide fiber comprising the steps:

a) fabricating a single mode or multimode optical waveguide fiber preform having a long axis, a core, and a clad, wherein any cross section of the preform, perpendicular to the long axis, is circular;

b) grinding, sawing, or otherwise removing peripheral portions of the preform to alter the preform surface such that any cross section of the preform taken perpendicular to the long axis has a shape which is essentially the same as the shape of any other cross section of the preform perpendicular to the long axis;

c) heating and drawing the preform along its long axis into a waveguide fiber having a core, a long axis and a circular cross section perpendicular to the long axis at any point along the long axis, to provide a waveguide fiber core having the shape of the altered preform.

16. The method of claim 15 in which step b) includes forming one or more indentations in the preform surface.

17. The method of claim 16 in which the fabricating step a) includes the step of fabricating a segmented core preform comprising, a central core region and at least one annular portion surrounding and in contact with the central core region, wherein the relative refractive index of the central region is different from the relative refractive index

of the annular portion and the one or more indentations penetrate at least into the annular portion.

18. A method of making a radially and azimuthally asymmetric single mode or multimode waveguide comprising the steps:

a) fabricating an optical waveguide fiber preform having a long axis, a core, and a clad, wherein any cross section of the preform, perpendicular to the long axis, is circular;

b) drilling or grinding or otherwise producing in the waveguide preform one or more holes which extend along the long axis;

c) heating and drawing the preform along its long axis into a waveguide fiber having a core, a long axis and a circular cross section perpendicular to the long axis at any point along the long axis, to provide a radially and azimuthally asymmetric waveguide fiber core.

19. A method of making a radially and azimuthally asymmetric single mode or multimode optical waveguide fiber comprising the steps:

a) fabricating at least two waveguide fiber core preforms each having a long axis;

b) inserting the at least two core preforms into a tube made of clad glass to form a core preform-tube assembly having a long axis, wherein interstitial voids are formed among the boundaries of the at least two core preforms and the inside of the tube;;

c) heating and drawing the assembly along its long axis into a waveguide fiber having a core, a long axis and a circular cross section perpendicular to the long axis at any point along the long axis, to provide a waveguide fiber having a radially and azimuthally asymmetric core.

20. The method of claim 19 further including the step, prior to step c), of inserting in the interstices formed among the at least two core preforms and the tube, clad glass having a shape selected from the group consisting of particles, rods, and microspheres.

21. The method of claim 19 wherein the fabricating step a) includes the step of fabricating a segmented core preform comprising, a central core region and at least one annular

portion surrounding and in contact with the central core region, wherein the relative refractive index of the central region is different from the relative refractive index of the annular portion.

22. A multimode optical waveguide fiber having a radial and azimuthal asymmetric core comprising:

a core region in contact with a surrounding clad layer, at least a portion of the core region having a refractive index which is greater than the refractive index of at least a portion of the clad layer;

the waveguide having a centerline parallel to the long dimension of the waveguide, and the waveguide having four core sectors each bounded by a first and a second plane, and a segment of the core region periphery intersected by the first and the second plane, wherein the first and second planes each contain the centerline and form at the centerline an included angle $\varphi \leq 180°$, wherein,

the core region is of cylindrical shape and a point in the core region has cylindrical coordinates, radius r, azimuth angle φ, and centerline height z, and the radius of the core region is $r = r_o$, and the refractive index changes along a radius portion Δr in the range $0 < \Delta r \leq r_o$, wherein,

the four core sectors have equal volume numbered consecutively from 1 to 4 in a counter-clockwise azimuth direction, and the boundary planes of each sector having an included angle of 90°, and sectors 1 and 3 have a radial change in refractive index defined by a function f(r), and sectors 2 and 4 have a radial change in refractive index defined by a function g(r).

23. The waveguide of claim 22, in which, g(r) is a step index and f(r) is an α- profile.

24. The waveguide of claim 22, in which, the four core sectors are of equal volume, the bounding planes of each sector having an included angle of 90°, the refractive index profile of each sector having a central portion of radius r_c and relative index Δ_c, extending between the planes bounding the sector;

a first annular region in contact with the central portion, having outer radius r_1, relative index Δ_1, and extending between the planes bounding the sector,

a second annular region in contact with the first annular region, having outer radius r_2, relative index Δ_2, and extending between the planes bounding the sector,

a third annular region in contact with the second annular region, having outer radius r_3, relative index Δ_3, and extending between the planes bounding the sector,

a first volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the first plane bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions,

a second volume of constant refractive index embedded in the core of the first sector and bounded on a first part of its surface by a part of the second plane bounding the sector and bounded on a second part of its surface by a part of the first, second, and third annular regions, wherein,

each of the remaining three sectors contain embedded volumes having surfaces bounded in a way corresponding to the volumes embedded in the first sector, wherein, the relative indexes and the radii follow the inequalities,

$0 \leq r_c < r_1 < r_2 < r_3 \leq r_o$ and $\Delta_c \geq \Delta_2 > \Delta_1 \geq \Delta_3$.

25. The waveguide of claim 22 in which the four core sectors each comprise a first glass volume having relative index Δ_1, and embedded in the first glass volume of each sector is an elongated volume of a second glass having relative index Δ_2, wherein the respective elongated volumes are arranged symmetrically about the centerline.

26. A multimode optical waveguide fiber having a radial and azimuthal asymmetric core comprising:

a core region in contact with a surrounding clad layer, at least a portion of the core region having a refractive index which is greater than the refractive index of at least a portion of the clad layer;

the waveguide having a centerline parallel to the long dimension of the waveguide, and the waveguide having four core sectors each bounded by a first and a

second plane, and a segment of the core region periphery intersected by the first and the second plane, wherein the first and second planes each contain the centerline and form at the centerline an included angle $\varphi \leq 180^{\circ}$, wherein,

the core region is of cylindrical shape and a point in the core region has cylindrical coordinates, radius r, azimuth angle φ, and centerline height z, and the radius of the core region is $r = r_o$, and the refractive index changes along a radius portion Δr in the range $0 < \Delta r \leq r_o$, wherein,

the core has three sectors, and each sector comprises a volume of a first glass of constant refractive index embedded in a volume of a second glass of constant refractive index, in which the refractive index of the first glass is greater than the refractive index of the second glass.

27. The waveguide of claim 26 in which each of the first glass volumes is an elongated body having its long axis aligned parallel to the centerline, wherein the perpendicular cross section of the elongated body is selected from the group consisting of a circle, an ellipse, and a parallelogram.

28. The waveguide of claim 26, in which the three core sectors each contain an elongated glass volume having a central portion, a first annular portion surrounding and in contact with the central portion, and at least one additional annular portion in contact with the annular portion which the at least one additional annular portion surrounds, wherein the long axis of each of the elongated structures is parallel to the centerline.

29. The waveguide of claim 28 in which the central portion is a cylinder having radius r_c and relative index Δ_c, and the annular regions are tubes having respective outer radii r_i and relative index Δ_i, where $i = 1 \ldots n$, and n is the number of annular portions, in which Δ_i for i = an even number is greater than Δ_i for i equal to an odd number.